CD-ROM—Serpentine Paper Drying Machine

Patent Application of

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For

TITLE: SERPENTINE PAPER DRYING MACHINE

CROSS-REFERENCE TO RELATED APPLICATION Not Applicable

FEDERALLY SPONSORED RESEARCH Not Applicable

SEQUENCE LISTING OR PROGRAM Not Applicable

BACKGROUND OF INVENTION—FIELD OF THE INVENTION

This invention relates to the drying a paper webs, specifically with configurations for through-air-drying of those webs.

BACKGROUND OF THE INVENTION

Paper products, e.g., tissues, have conventionally been manufactured by forming a wet paper web on a fabric-carrying sheet, which then carries the paper web through a pressing section to remove the excess water from the web. After pressing the web to remove excess water, the paper web would then be fed to a separate drying section to fully remove the remaining moisture from the web. This step of pressing the web, however, reduces bulk and absorbency. Therefore, as opposed to leaving the web as a flat sheet on a single plane, rotatable air-heated drum dryers over which the web traveled were utilized in combination with an imprinting fabric sheet. Dryer hoods and air supply ducts are widely used in connection with these rotary drums, wherein pressurized drying air is introduced into the roll or at various points in the hood to contact one exposed surface of the wet web as it progresses around the dryer with the exit path for the air being positioned on the other side of the rotary drum. This process is known as through air drying (TAD). U.S. Pat. No. 3,303,576 issued to Sisson discloses one such drying assembly in which a moving stream of pressurized drying air is circulated about a paper web traveling about the periphery of a rotatable roll having apertures formed therein. Sisson utilizes a system where the hot drying air travels from the inside of the rotatable roll to the outside through the apertures, while the web travels about the outer surface of the roll. With such rotatable rolls usually being composed of metal, this inside-to-outside type drying

requires smaller diameter, multiple rolls because a larger diameter results in the web and fabric sheet lifting away from the roll surface at the air flows and pressures of commercial interest.

U.S. Pat. No. 3,432,936 to Cole et al. avoids the problems with inside-to-outside drying by employing a configuration, which moves drying air from the exterior of a rotatable roll through the paper web and into the interior of the rotatable roll, otherwise known as outside-to-inside drying. Web and fabric sheet lifting do not impose airflow restrictions in outside-to-inside drying, because the air is blowing them onto the roll surface. Also, this configuration positions the metal rotatable roll on the cool side of the paper web, which allows for improved maintenance and drum life. However, when two or more of these rotatable rolls employing outside-to-inside drying are used, at least two carrying rolls must contact the paper web. Whenever wet paper webs contact carrying rolls, machine run ability problems as well as product quality problems may be encountered, especially when the web is wet in the range of 65% moisture and higher moisture. One of the most important shortcomings associated with this paper drying machine is that the paper web must come into contact with a carrying roll whenever more than one rotatable drying roll is employed. Further, machines that have one roll have limited drying capacity and are therefore of limited commercial interest.

However, the most efficient use of space in these machines would be to use a combination of inside-to-outside drying rolls with outside-to-inside drying rolls. U.S. Pat. No. 1,718,573 issued to Millspaugh discloses a paper making machine which discloses removing moisture from a paper web in an outside-to-inside fashion using a suction roll followed by an inside-to-outside removal of moisture by forcing steam through the paper web as it passes over a blower roll. It should be noted, however, that the device disclosed by Millspaugh utilizes steam with its blower roll. Because of the water content of steam, the medium cannot be used to dry a sheet to the required solids content. Furthermore, it is economically more efficient and proficient to employ heated air rather than a combination of air and steam when using a blowing device to dry a wet paper web.

U.S. Pat. No. 5,636,452 to Thorp et al. discloses a drying apparatus having two TAD rolls with one TAD employing inside-to-outside drying air and the other TAD roll employing outside-to-inside drying air. Thorp et al. is limiting in that its drying capacity is not sufficient to reach world class speeds found in present drying machines. The surface drying area of the two TAD rolls of Thorp et al. is less than that found in typical new TAD drying machines. Additionally, the configuration of Thorp et al. produces limited wrap of the paper web around its outside-to-inside drying drum, providing less drying surface area. In order to increase wrap, without the use of an outside roll that would touch the paper web, both TAD rolls of Thorp et al. are oriented at an angle. This leads to the need to have the exhaust hoods positioned at an angle as well, resulting in a complex and expensive design, especially when retrofitting existing machines.

US. Pat. No. 6581301 to Thorp et al. discloses a paper drying machine that reduces some of the difficulties inherent in prior known devices by permitting all of the hoods to be positioned in the customary vertical position, to provide greater flexibility and take advantage of vertical space, which is typically more available when retrofitting existing drying machines. However, the invention requires at least two separate hot air systems, which is both capital intensive and requires

additional building space. Secondly, it does not benefit from the added drying inherent in between the rotary drums or rolls that is possible if one hot air system can be used that continually dries the web path from the first drum to the last.

It is an object of the present invention to provide a paper drying machine that reduces or wholly overcomes some or all of the difficulties in prior known devices. Particular objects and advantages of the invention will be apparent to those skilled in the art, that is, those who are knowledgeable or experienced in this field of technology, in view of the following disclosure of the invention and detailed description of preferred embodiments.

SUMMARY

The principles of the invention may be used to advantage to provide a drying machine having improved drying capacity within a limited amount of space. Such a construction advantageously uses only one hot air system, one supply plenum hood and one exhaust hood system to supply all TAD section drums and rolls. This provides greater flexibility, and takes better advantage of vertical and horizontal space, which is typically more important when retrofitting existing drying machines. Additionally, the present invention may provide greater wrap around its air permeable drying drums in certain embodiments. A further benefit of the new approach is the potential addition of smaller diameter air-permeable or non-air-permeable carrier rolls touching the paper web, once the dryness of the sheet has achieved the level required to avoid roll build up, in contrast to previous inventions that used only air permeable drying drums with high open area for drying. This addition of more closely spaced carrier rolls can be utilized to substantially increase the TAD drying length possible within an existing machine.

A paper drying apparatus to dry a paper web carried on a fabric sheet includes a first rotatable drum to carry a paper web. A second rotatable drum (or carrier roll) to carry the paper web is positioned downstream of the first rotatable drum with respect to the paper web carried by the first and second rotatable drums. A third rotatable drum (or carrier roll) to carry the paper web is positioned downstream of the second rotatable drum (or roll) with respect to the paper web carried by the first, second, and third rotatable drums. Since the drums are arranged in a serpentine fashion, the same, vertical direction of air can be used to supply all rolls and always blow the sheet into the carrier fabric, while it is being dried, ensuring that it remains attached to the carrier fabric during the drying process, even though some rotatable drums have inside-to-outside air flow and others have outside-to-inside air flow.

By the nature of the sheet and dryer support fabric remaining inside the drying system in between rotatable drums and carrier rolls, the maximum drying benefit is derived from the system, avoiding the cooling affect between stations of previous inventions.

From the foregoing disclosure, it will be readily apparent to those skilled in the art, that is, those who are knowledgeable or experienced in this area of technology, that the present invention provides a significant advance. Preferred embodiments of the paper drying machine of the present invention can provide improved drying capacity, while reducing the cost of

retrofitting existing paper drying machines. These and additional features and advantages of the invention disclosed here will be further understood from the following detailed disclosure of preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments are described in detail below with reference to the appended drawing. FIG. 1 is a schematic side view of a paper drying machine in accordance with a preferred embodiment of the present invention. The figure referred to is not drawn necessarily to scale and should be understood to present a representation of the invention, illustrative of the principles involved. Some features of the serpentine paper drying machine depicted in the drawings have been enlarged or distorted relative to others to facilitate explanation and understanding. Paper drying machines as disclosed herein, will have configurations and components determined, in part, by the intended application and environment in which they are used.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. 1, a paper drying device 1 in accordance with a preferred embodiment of the present invention is illustrated for removing moisture from a wet paper web **4,** which is the product of a paper making machine, not shown here. Paper drying device 1 is supported on a floor or other surface 3. Paper web 4 is carried from a paper making process (not shown) to drying device 1 by a fabric sheet 2, wherein fabric sheet 2 travels about the perimeter of a couch roller 5 and a roller 6. In between rollers 5 and 6, paper web 4 is contacted by and transferred to a fabric sheet 8 as fabric sheet 8 passes by a pick-up device or shoe 10. Pick-up shoe 10 may comprise a transfer roller, transfer shoe or any other structure to transfer paper web 4 from fabric sheet 2 to fabric sheet 8. Such transfer devices often employ a vacuum to aid in the transfer of the paper web from one transfer fabric to another. Fabric sheet 8 conveys paper web 4 throughout drying device 1 and forms a closed loop through drying device 1, returning to the paper web transfer area at pick up shoe 10. The paper web 4 is transferred to fabric sheet 8, fabric sheet 8 carries paper web 4 through the drying chamber 12. As paper web 4 passes downstream through paper drying device 1, it passes past a sealing roll, 13, and then around a first rotatable drum 14, a second rotatable drum, 15, and then a series of serpentine carrier rolls, 16 to a seal roll 17 at the other end of the drying chamber. The drying chamber has a heated air supply 18 and an exhaust hood 19 for providing an exit for the heated air from within the drying chamber.

Rotatable drums 14 and 15 have a porous surface permeable to air so that the drying air supplied by air supply 18 passes through the surface of drum 14 and to the interior 20 of drum 14. and on through the web to the exhaust hood 19. The web continues down around rotatable drum 15 as air continues to be supplied by drying chamber 18 and exhausted from the interior 21 of roll 15 and into the exhaust hood 19. At this point the web is dry enough that it can be contacted by air permeable or solid carrier rolls 16 which are located in a serpentine arrangement until the desired moisture of web 4 has been achieved. The diameters and numbers of rotatable rolls 14 and 15 can be varied based on process requirements to achieve dryness that will permit a carrier roll to contact the web. The illustrated embodiment, employs through-air-drying (TAD) to remove moisture from paper web 4 while it travels around the perimeter of rotatable drum 14. Thus, air supply 18 forces air in the direction of arrow A into the interior 20 of drum 14 on which fabric sheet 8 does not travel. The air then travels from the interior 20 of drum 14 through the porous surface of drum 14 in the direction of arrow A toward exhaust hood 19. Accordingly, after the air passes through the permeable surface of the drum, the air is forced through paper web 4

and fabric sheet 8, both of which are traveling about the surface of rotatable drum 14. The path of the drying air is known as inside-to-outside TAD, because the air is traveling from the inside of drum 14 to the outside of drum 14 while it is removing moisture from paper web 4. While the inside-to-outside drying air exits rotatable drum 14 and passes through paper web 4, the air applies a force to lift fabric sheet 8 and paper web 4 from the surface of drum 14, wherein the tautness of fabric sheet 8 resists this force and holds paper web 4 in abutment to drum 14. The restricting force due to the tension of fabric sheet 8 is calculated as F = T divided by R, where T is the tension of the fabric sheet in pounds per linear inch, and R is the radius of the roll in inches. Since this restraining force is inversely proportional to the roll radius, larger rolls have a lower restraining force. Therefore, rolls having inside to outside air flow typically have a diameter less than 10 feet. The size of rotatable drum 14 will be dependent on fabric tension capabilities and layout constraints.

After leaving rotatable drum 14, the fabric sheet 8 and paper web 4 continue to drum 15 which employs TAD to further dry the paper web 4; however, second rotatable roll 15 employs outside-to-inside drying air, as opposed to the inside-to-outside drying air used in rotatable roll 14. Fabric sheet 8 enters second rotatable drum 15 and travels about its outer surface, whereon fabric sheet 8 is in abutment with the surface of rotatable drum 15. The heated air supply 18 now forces heated air, in the direction of arrow A, initially through paper web 4 and then passes through fabric sheet 8, and finally the air passes through the air permeable surface of rotatable drum 15 into the interior 21 or rotatable drum 15.

After passing into the interior of drum 15, the air passes in the direction of arrow A through a portion of rotatable drum 15 on which fabric sheet 8 does not travel, and subsequently to exhaust hood 19. While rotatable drum 15 may be similar in size to rotatable drum 14, rotatable drum 15 can be larger in diameter than drum 14, as the drying air does not exert a lifting force on the fabric sheet or paper web. A larger drum is generally more effective in removing moisture from the paper web. After leaving second drying chamber 30, fabric sheet 8 next carries paper web to a series of carrier rolls 16.

After traveling through third drying chamber 12, fabric sheet 8 conveys paper web 4 from seal roll 17 to a final rotatable drying drum 22, a steam heated drum conventionally known as a Yankee or crepe dryer. Drum 22 typically has a hood (not shown), and provides the opportunity to crepe (also not shown). Drying drum 22 and its associated creping impart dry bulk, softness, drapability, and machine direction stretch to paper web 4. Fabric sheet 8 and paper web 4 proceed between the periphery of a pressure roll 23 and drying drum 22, wherein pressure roll 23 abuts fabric sheet 8 and transfers paper web 4 from fabric sheet 8 to the perimeter of drying drum 22. Paper web 4 then rotates along with the perimeter of drying drum 22 in a final drying procedure for paper web 4. Fabric sheet 8 then continues to travel along its loop about the perimeter of a series of carrier rolls 24, returning to pick up shoe 10 and then repeating the above stated process of drying paper web 4. As fabric sheet 8 travels back to pick up shoe 10, it passes through a fabric cleaning and conditioning device 25 to remove residual fibers, fabric release agents, and paper making chemicals from fabric sheet 8. In addition, a guide roll 26 is adjustably mounted so that its position may be altered to modify the position of fabric sheet 8 as it travels through the drying *loop*. There is also a stretch roll (not shown) to adjust the length and tension of fabric sheet 8. After passing through fabric cleaning and conditioning device 25, fabric sheet 8 is treated by shaping box 27. Shaping box 27 provides for wet shaping of paper web 4 by pulling the fibers of the web into interstices of fabric sheet 8. As paper web 4 is dried, voids, or pillows, are created in the web, providing increased absorbency for the paper web. Following shaping box 58, fabric sheet 8 is treated by

vacuum box 28, providing additional de-watering and shaping of fabric sheet 8 if needed. It is to be appreciated that in certain preferred embodiments, the position of shaping box 27 and vacuum box 28 are reversed with respect to one another so that fabric sheet 8 is first treated by vacuum box 27 and then by shaping box 28.

In a preferred embodiment, the direction of each of arrow A, and thus, the direction of airflow through the drying chambers, is substantially perpendicular to surface 3. Consequently, the exhaust hood is located vertically above a corresponding air supply. In this configuration, drying chamber 12 is considered to be aligned vertically with respect to surface 3 and drying device 1. The vertical orientation of the drying chambers allows greater use of vertical space in drying device 1, which is typically more available than horizontal space, especially in existing drying machines. This configuration enables existing drying machines to be retrofitted with TAD dryers in a cost effective manner, utilizing existing designs and avoiding costly reconstruction of these large and expensive machines. The minimal space required for this TAD roll configuration allows current paper drying machines to be adapted to include this improved configuration without having to move the large components in the drying process, such as the Yankee dryer 22, while providing greater drying capacity. Therefore, the operational downtime of a paper drying machine which would result from adapting the paper drying machine to incorporate this improved TAD roll configuration would be minimal.

The configuration of the TAD rolls and fabric sheet 8 in the present invention provides greater drying length and improved drying capacity. Preferred embodiments of the present invention can provide sufficient drying capacity to achieve world class speeds on the order of 5,000 feet per minute on 13 pound per 3,000 square feet tissue or towel product. The configurations rotary drum and carrier roll diameters can vary in size and numbers dependent on the process requirements and the physical restraints of the practical installation.

Such a configuration is also an improvement over TAD machines having a wet creping action followed by drying with no Yankee dryer or dry creping. The present invention provides an improved product with dry crepe, and, therefore, ample machine direction stretch for desired converting functions. In light of the foregoing disclosure of the invention and description of the preferred embodiments, those skilled in this area of technology will readily understand that various modifications and adaptations can be made without departing from the scope and spirit of the invention. All such modifications and adaptations are intended to be covered by the following claims.